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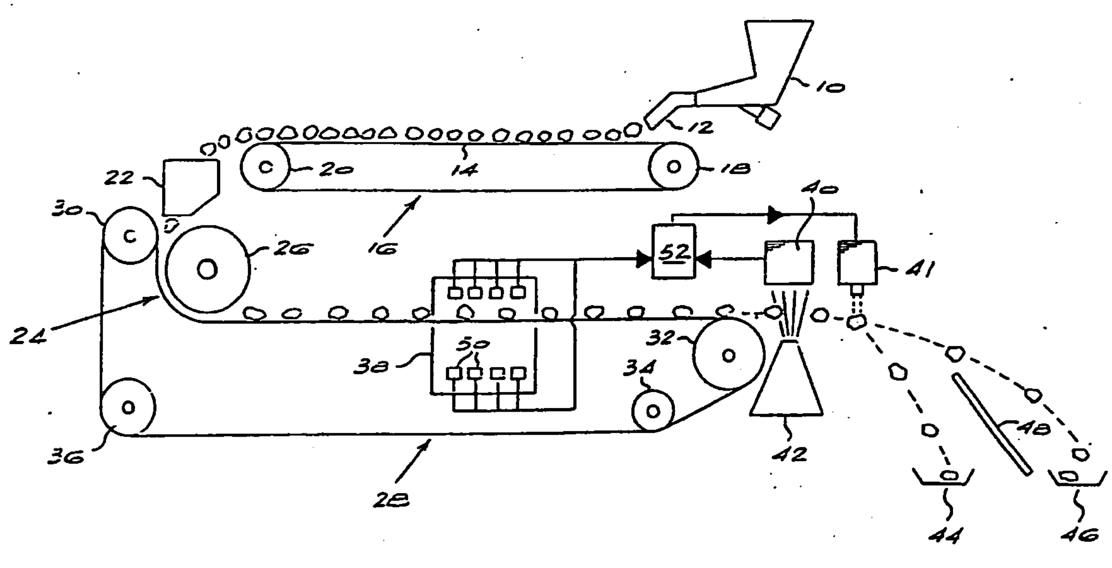
(54) Sorting ore particles

(57) Particulate material e.g. ore particles is sorted on the basis of the degree of attenuation of microwave radiation by the individual particles. The particles are fed *via* belts 16, 28 to a detection zone 28 which includes a microwave chamber in which is located wave guide antennae (50) which apply microwaves to the chamber and detect signals propagated through the particles as they pass through the chamber. Processing unit (52) analyses the signals and determines which of the particles exhibit a selected signal attenuation characteristic. Line scan camera (40) provides signals to unit (52) indicative of the relative rise and location of the particles and on the basis of these signals unit (52) controls ejector manifold (41) to eject the relevant particle. Particles of kimberlite can be sorted from gabbro using a microwave frequency of 35 GH_z, particles sorted on the basis of water content using a microwave frequency of $246H_z$, particles of gold bearing rock from waste rock and particles of coal from waste rock.



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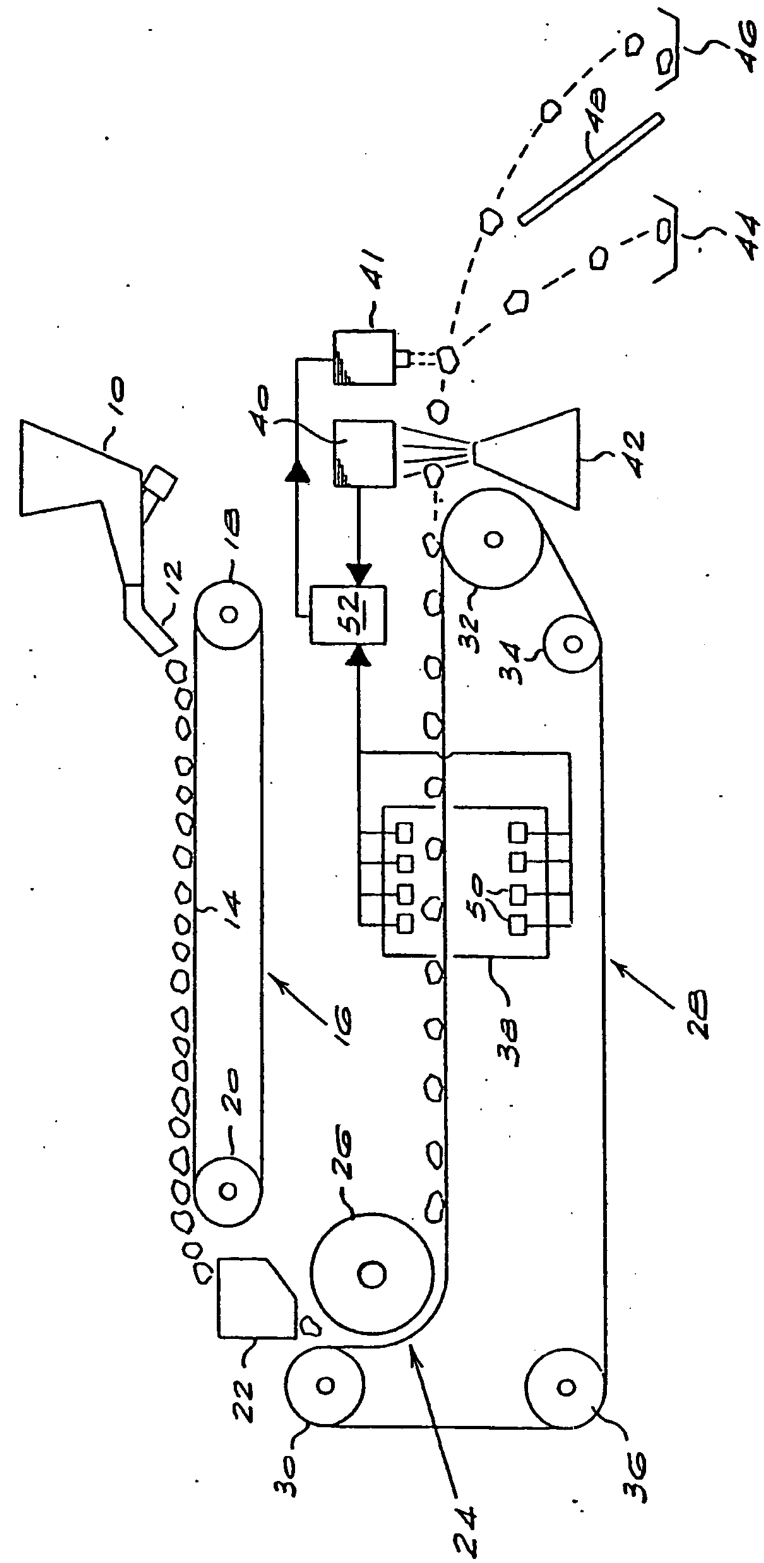

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"SORTING APPARATUS AND METHOD"

BACKGROUND TO THE INVENTION

THIS invention relates to a sorting method and apparatus.

All rock types are composed of an aggregate of minerals of a certain composition in a certain proportion to one another. All rock types also contain a certain volume of water which is inherent, bound up in the form of waters of crystallisation, pore water or surface water. The different minerals in the rock will each have a different excitation characteristic when subjected to microwave radiation.

At Premier Mine in the Republic of South Africa, a sill of gabbro in the diamond pipe, which contains diamond-bearing kimberlitic ores, has resulted in dilution of the kimberlite with gabbro and difficulties in sorting the desired kimberlitic ores from the unwanted gabbro. In this particular case, it is known that kimberlite has a higher porosity and carbon content than does gabbro or other non-kimberlitic ores, such as felsite, which are encountered. In addition, its higher porosity means that it contains more water than the other rock types.

The present invention seeks to provide a sorting method and apparatus which relies on different responses to microwave irradiation.

SUMMARY OF THE INVENTION

The invention provides a method of sorting a mass of ore particles into fractions, the method including the steps of irradiating the particles with electromagnetic radiation at a predetermined frequency or frequencies in the microwave part of the spectrum, analysing the signals which are propagated through the particles, and separating those particles which exhibit a predetermined signal attenuation characteristic from other particles which do not exhibit such predetermined signal attenuation characteristic.

In a preferred form of the invention the predetermined frequency of the electromagnetic radiation which is used is the frequency or frequencies at which the target mineral or minerals or water strongly attenuate the radiation. In a case where the method is used to separate particles on the basis of signal attenuation by water associated with the particles, the frequency may be of the order of 24GHz, corresponding to a water absorption peak.

In one particular application of the method, it can be used to separate particles of kimberlitic ore from other particles, such as gabbro, in which case the frequency which can be used corresponds to either the water absorption peak at about 24GHz, or at about 35GHz at which frequency kimberlite strongly attenuates the signal.

The invention also provides apparatus for sorting a mass of particles into fractions, the apparatus including a microwave chamber in which the particles of the mass are subjected to electromagnetic radiation at a predetermined frequency or frequencies in the microwave part of the spectrum, means for detecting the signals propagated through the particles, means for analysing the detected signals and means for separating particles

exhibiting a predetermined signal attenuation characteristic from other particles which do not exhibit such characteristic.

The means for detecting the propagated signals may, for instance, be one or more wave guide antennae.

BRIEF DESCRIPTION OF THE DRAWING

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawing which illustrates a sorting apparatus schematically.

DESCRIPTION OF AN EMBODIMENT

The drawing shows a schematic view of a sorting apparatus comprising a vibratory feeder 10 which receives particulate material from a hopper (not illustrated) and which feeds the particles through a discharge chute 12 onto the upper run 14 of a feed belt 16 running around rollers 18 and 20. The feed belt transports the particles to the left in the drawing and discharges them into a feed chute 22 which deposits the particles in an orderly fashion into the nip 24 between a stabiliser wheel 26 and the upper run of a main belt 28 which runs around a series of rollers 30 to 36.

The main belt 28 transports the particles through a detection zone 38, about which more will be said later. The main belt 28 discharges the particles from its upper run in free flight. At an early stage in the free trajectory described by the particles, they are viewed by a line scan camera 40 mounted opposite a light source 42. Downstream of the line scan camera 40 is an ejector manifold 41 which issues, through a nozzle or nozzles, a short

blast of fluid, typically air, whenever a desired particle passes by. Such particles are ejected from their trajectory by the blast and fall into a bin 44 while other, non-ejected particles continue in free flight into a reject bin 46 . A splitter plate 48 is provided between the bins to ensure that efficient separation takes place.

As thus far described, the apparatus is conventional and may typically be an apparatus of the type available from Ore Sorters under the designation "Model 17".

According to the present invention, the detection zone 38 includes a microwave chamber in which is located a series of wave guide antennae, shown schematically at 50, which apply microwave radiation to the chamber and which detect the signals propagated through the particles as they pass through the chamber.

The wave guide antennae will be designed in a particular case for the known parameters and in accordance with known principles. It should, however, be borne in mind that the antennae should in all cases be smaller in size than the known size of particles which are to be sorted, to ensure that no radiation is able to bypass a particle entirely.

In practice, the particles are arranged into parallel streams on the main belt by the feed system, and wave guide antennae will be provided for each stream on the belt.

The propagated signals detected by the antennae are fed to a processing unit 52. The processing unit analyses the signals and determines which of the particles exhibit a selected signal attenuation characteristic. Signals from the line scan camera,

which are indicative of the relative size and location of the particles, are also fed to the processing unit. When a particle having the selected signal attenuation characteristic is detected, the processing unit 52 issues, at the appropriate time, a signal to the ejector manifold 41 so that a fluid blast is produced at the correct instant. The relevant particle is ejected from its normal trajectory and falls into the bin 44. The manifold 41 does not produce a fluid blast for other particles which do not exhibit the selected signal attenuation characteristic with the result that those other particles continue in free flight into the reject bin 46.

EXAMPLES

Example 1

In this example, the technique of the invention is used to differentiate between particulate samples of gabbro and kimberlite. A total of ten similarly sized samples of gabbro and ten samples of kimberlite were soaked in water for 24 hours.

The samples were placed between the ports of a microwave transmission line and were subjected to microwave radiation at a frequency of 35GHz with a transmission power of 1mW. The propagated signals were detected and analysed using known techniques to determine the signal attenuation characteristic for each particle. The results are tabulated below.

SAMPLE NUMBER	GABBRO ATTENUATION (dB)	KIMBERLITE ATTENUATION (dB)
1	2.9	17.5
2	2.9	17.2
3	2.6	18.7
4	2.1	16.2
5	2.2	18.8
6	1.8	14.2
7	1.8	20.3
8	1.9	20.8
9	2.9	21.0
10	2.7	20.0

Clearly, the signal attenuation in the case of the kimberlite particles was considerably higher than that in the case of the gabbro particles and the attenuation characterics of individual particles therefore provides a good basis for discrimination between the particles. The frequency of 35GHz which was used in this example corresponds to a strong kimberlite absorption peak.

<u>Example 2</u>

In this example, the signal attenuation is shown to provide a good basis for discrimination between gold-bearing and non gold-bearing rock. Five particulate samples of Carbon Leader Reef rock (known to have a high gold content) and five of waste rock mined from the hanging and footwalls in a gold mine stope were subjected to microwave radiation at a frequency of 35GHz. In each case, the particle size was defined as -60+30mm mesh.

All the samples were mined at Vaal Reefs Gold Mine in the Republic of South Africa. The propagated signals were detected and analysed and the results are tabulated below.

SAMPLE NO	CARBON LEADER REEF ATTENUATION	WASTE ROCK ATTENTUATION
1	20,9dB	0,5dB
2	21,2dB	0,4dB
3	21,3dB	0,5dB
4	21,0dB	0,5dB
5	21,1dB	0,6dB

Clearly, the signal attenuation by gold-bearing particles was far higher than that for barren particles.

Example 3

This example also illustrates the use of the invention in sorting gold-bearing and barren rock samples. A microwave frequency of 10GHz was used in this case and one sample each of Carbon Leader Reef rock, Vaal Reef rock (known to be less rich in gold than Carbon Leader Reef) and waste rock were tested. In the case of the Carbon Leader Reef sample, a signal attenuation of $8dBcm^{-1}$ was detected, in the case of the Vaal Reef sample, a signal attenuation of $2dBcm^{-1}$ was detected and in the case of the waste rock sample, a single attenuation of $1dBcm^{-1}$ was detected. The results obtained in this example indicate that the invention may be used not only to discriminate between gold-bearing and non gold-bearing samples, but also between different grades in gold-bearing samples.

Example 4

This example illustrates the use of the invention in sorting coal from waste rock. Coal and waste rock samples mined at New Denmark Colliery in the Republic of South Africa were subjected to microwave radiation at a frequency of 10GHz. In the case of the coal sample, the signal attenuation was determined to be $9dBcm^{-1}$ while in the case of the waste rock sample, the signal attenuation was determined to be $4dBcm^{-1}$. Accordingly a clear basis for discrimination is seen to exist in this case as well.

It should be noted that the microwave frequency used in a particular case will depend on the nature of the particulate material which is to be sorted. In practice, the frequency used will be one at which a chosen material or constituent thereof exhibits a strong absorption peak. In some cases, it may be desirable to sort materials on the basis of their water composition, in which case a microwave frequency of 24GHz would be used, this frequency corresponding to a strong absorption peak for water. In fact, this frequency could be used in the sorting of kimberlite from gabbro, the water content of kimberlite being higher than that of gabbro as pointed out previously. Experimentation in each case will indicate the optimum frequency for a particular sorting application.

CLAIMS

1.

A method of sorting a mass of ore particles into fractions, the method including the steps of irradiating the particles with electromagnetic radiation at a predetermined frequency or frequencies in the microwave part of the spectrum, analysing the signals which are propagated through the particles, and separating those particles which exhibit a predetermined signal attenuation characteristic from other particles which do not exhibit such predetermined signal attenuation characteristic.

2.

The method of claim 1 wherein the predetermined frequency or frequencies is or are the frequency of frequencies at which a target mineral or water, or both such mineral and water, strongly attenuate microwave radiation.

3.

The method of claim 2 when used to sort particles of kimberlite from particles of gabbro, the microwave frequency being of the order of 35GHz.

4.

The method of claim 2 when used to sort particles on the basis of water content, the microwave frequency being of the order of 24GHz.

5.

The method of claim 2 when used to sort particles of kimberlite from particles of gabbro, the microwave frequency being of the order of 24GHz.

6.

The method of claim 1 or claim 2 when used to sort particles of gold-bearing rock from waste rock.

7.

The method of claim 1 or claim 2 when used to sort particles of coal from waste rock.

8.

Apparatus for sorting a mass of particles into fractions, the apparatus including a microwave chamber in which the particles of the mass are subjected to electromagnetic radiation at a predetermined frequency or frequencies in the microwave part of the spectrum, means for detecting the signals propagated through the particles, means for analysing the detected signals and means for separating particles exhibiting a predetermined signal attenuation characteristic from other particles which do not exhibit such characteristic.

9.

The apparatus of claim 8 including wave guide antennae for irradiating the particles and for detecting the propagated radiation.

10.

The apparatus of claim 9 wherein the wave guide antennae have a size less than that of the particles to be sorted.

11.

A sorting method substantially as herein described with reference to the accompanying drawing and examples.

12.

A sorting apparatus substantially as herein described with reference to the accompanying drawing.

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